

Tannin Content of Sitka Spruce Bark

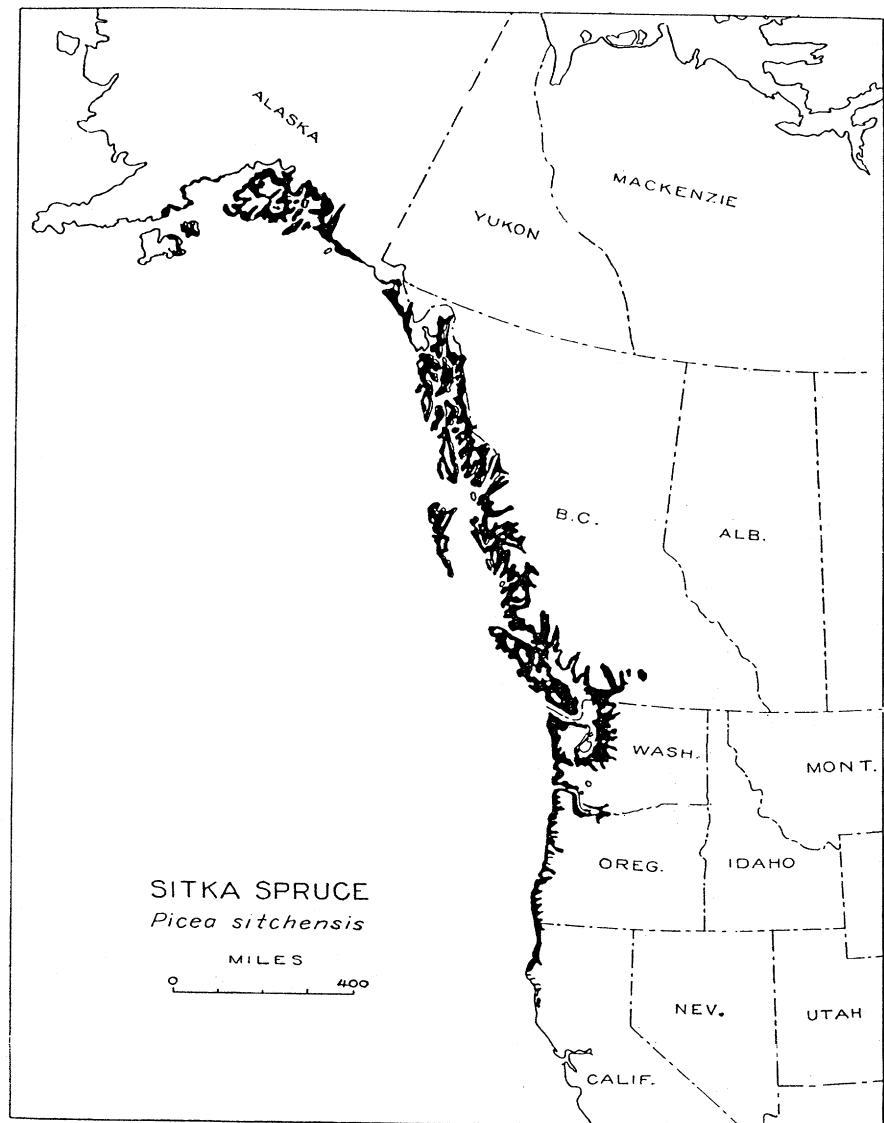
By R. W. FREY, *Principal Chemist* and I. D. CLARKE, *Chemist*,
Hides, Tanning Materials, and Leather Division,
Eastern Regional Research Laboratory,
Bureau of Agricultural Chemistry
and Engineering

One of the waste products of the Pacific Northwest is the bark of the Sitka spruce, *Picea sitchensis* (Bong.) Carr. A few analyses of this bark have been reported, which indicate that it contains appreciable amounts of tannin. However, little or no use of the bark has ever been made by the tanning industry of this country.

The Sitka spruce is the largest of the eighteen species of *Picea* in the northern hemisphere. It is found growing in a narrow belt along the Pacific Coast from northern California to Alaska and not more than 40 to 50 miles inland.

Pure stands of Sitka spruce are the exception rather than the rule. Usually it is associated with western hemlock, Douglas fir, western redcedar, grand fir, Pacific silver fir, Pacific yew, and some other species. Sitka spruce is one of the most rapid growing conifers in the Pacific Northwest. In twenty years trees reach a diameter in Oregon and Washington of from 2 to 4 inches and a height of about 30 feet. In forty years the diameter is about 9.5 inches and height 70 feet. The average maximum size of about 200 to 240 feet in height and 40 to 70 inches in diameter is attained in from two hundred to four hundred years.

In 1930 the stand of Sitka spruce was estimated at 11,130,000,000 board feet in the United States, 18,511,000,000 board feet in Alaska, and 16,165,-



(Prepared by U. S. Forest Service)
FIGURE I. Botanical range of Sitka spruce.

000,000 board feet in British Columbia.¹ Between 1928 and 1937 the average annual cut for lumber was 179,000,000 board feet and for pulpwood 85,000 cords (equivalent to 42,500,000 board feet). The total cut for all purposes during this period was about 240,000,000 board feet annually.¹

Ordinarily the lumber is used for boxes, crates, planing mill products, sashes, doors, and general millwork. The lumber is light in weight and

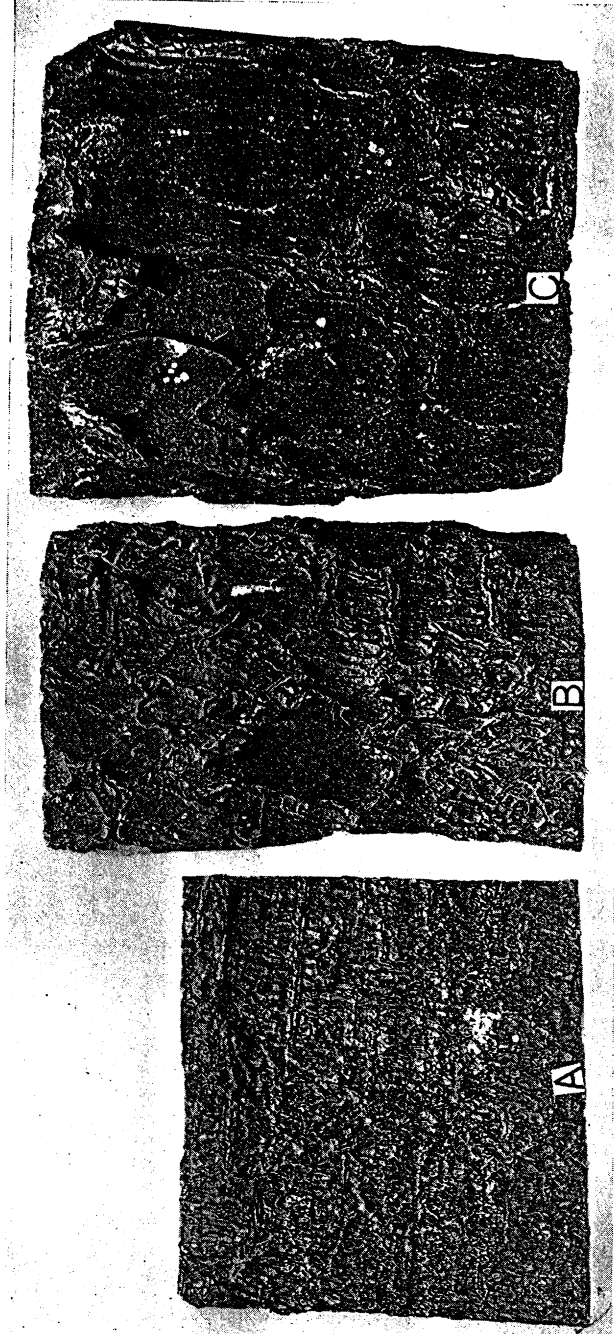


FIGURE II. Sitka spruce bark of different ages showing development of cups.
"A"—24 years old; "B"—81 years old; "C"—176 years old.

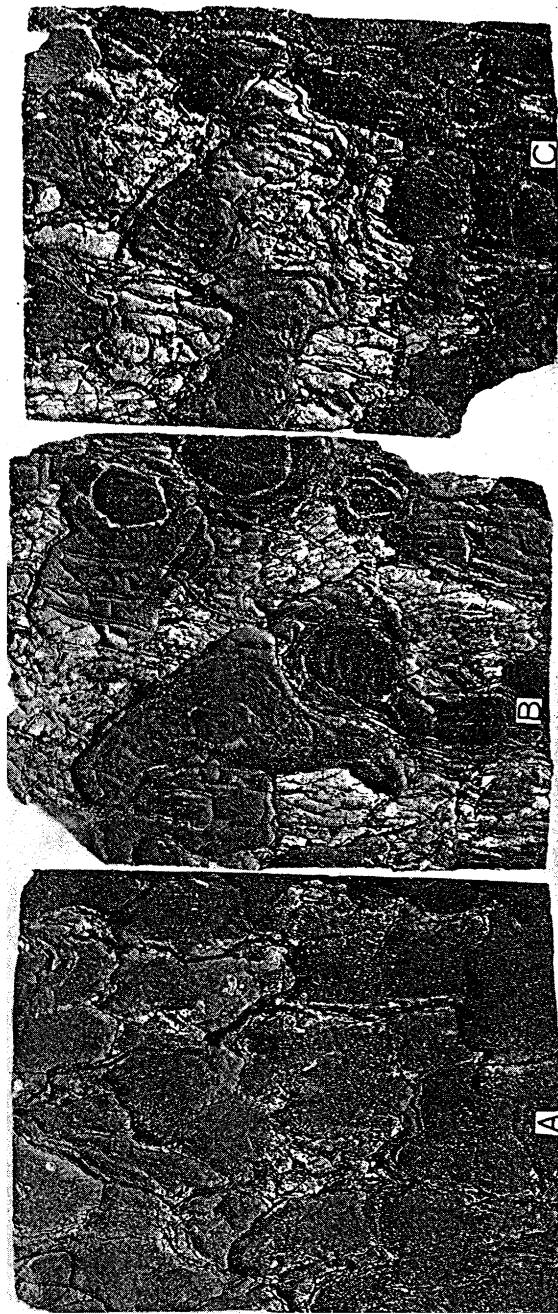


FIGURE III. Bark collected at different heights from a Sitka spruce tree 186 years old.
"A"—at 4 feet from ground; "B"—at 90 feet; "C"—at 160 feet.

strong in proportion to its weight. Because it can be obtained in clear, straight-grained, large pieces of uniform texture the lumber is exceptionally valuable for aircraft construction, and during the first World War the annual cut rose to 508,000,000 board feet.¹ The indications are that the annual cut will again attain this figure when the defense program has reached its peak.

Sitka spruce bark is distinctive in appearance. Cary² states that "the thin, stiff, cupped and elliptical dark purple-gray scales, one or two inches in diameter, make this species easily distinguishable from its associates in the stand." In Figures II and III several specimens of Sitka spruce bark are shown. In Figure II, sample "A" is from a tree 24 years old; "B" is from one 81 years old; and "C" is from a tree 176 years old. In the youngest bark the cups are not developed. They are present, however, in the bark from the 81-year old tree, but are not as pronounced as those in the oldest of these three specimens.

In Figure III there are shown pieces of bark taken at three different heights from a tree 186 years old, which grew at Lincoln Beach, Oregon. Sample "A" was taken 4 feet from the ground; "B", 90 feet; and "C", 160 feet. Bark from the upper part of the trunk is quite silvery. Little or none of this coloration is found near the base of the tree. Cups are prominent at all levels.

Attention was attracted in particular to Sitka spruce bark by a sample from Washington that showed upon analysis the surprisingly high content of 37 per cent tannin. One of the first reports on western spruce* was by Benson and Thompson,³ who gave the tannin content of sawmill bark as 5.88 per cent and sawmill slabs as 3.69 per cent. The authors stated that no history of the logs was available but that they probably had been floated in water for some time. In a discussion of this report Benson, Thompson, and Wilson⁴ stated that the tannin was low because a large portion of it had been leached out in floating the logs to the mills.

Apparently the only reported work on the tannin content of Sitka spruce bark from unfloat logs is that by Clark and Andrews,⁵ who studied seasonal variation. Their samples were taken at Kingcome Inlet, British Columbia from trees either standing or just felled, and were selected as typical. They found the maxima of 17.19 and 17.54 per cent in bark collected on April 12 and November 15, respectively. The minimum values were 12.01 per cent in bark collected January 5 and 15.10 per cent in that taken August 15.

The results reported in the literature on tannin content appear quite at variance with that of 37 per cent previously mentioned. In view of this, together with the increased amount of spruce bark becoming available and the advisability at this time of scrutinizing all possible domestic supplies of

tannin, the acquiring of more adequate data on the tannin content of this bark seemed desirable.

Arrangements were made accordingly with the Forest Service of the U. S. Department of Agriculture to gather for analysis a rather comprehensive collection of samples of Sitka spruce bark. Twenty-six samples were supplied together with complete data as to location, environment, and age of tree from which they were obtained. These included a set of ten samples from above Lake Quinault in the Olympic National Forest, Washington, and a group of sixteen from the Cascade Head Experimental Forest, Oregon. All of these samples were taken from trees that had been felled recently. The portion of the bark removed in each case for the sample entirely encircled the trunk. To include a study of the influence of height, samples were taken at three locations on the tree. These were stump height, halfway up the trunk, and near the top of the trunk.

Five additional samples from two trees only a few rods apart near Copalis, Washington and within a few miles of the ocean, were also obtained through the Chamber of Commerce of Hoquiam, Washington.

Analysis of the bark was made by the methods of the American Leather Chemists Association except for fixable tannin, which was determined by the Wilson-Kern procedure.⁶ The results are given in Table I.

The average tannin content of all the samples is 24.1 per cent, a comparatively high value. The results vary, however, from 11.2 to 37.2 per cent. This variation appears to be related to both height of sample from the ground level and age of tree. For old trees from the Quinault Valley, Washington, the average tannin content of the bark from near the ground was 13 per cent. At about midway the trunk it was 18 per cent and near the top, 28 per cent. With the collection of barks from the Cascade Head Experimental Forest, Oregon, the corresponding values for old trees were 17, 31, and 28 per cent and for young trees, 22, 28, and 31 per cent. In the case of old trees the tannin content of the bark from near the base of the tree is roughly a little more than one-half of that of bark from near the top. With young trees it is approximately three-fourths.

Bark from the base of old trees is lower in tannin than that from the corresponding location on young trees. A comparison of samples taken at about stump height from trees of different ages shows that the average tannin content of the bark from seven trees over 155 years old is 15.7 per cent, whereas those of the bark from four trees ranging from 70 to 81 years old and two trees 24 years old are, respectively, 24.1 and 25.2 per cent.

This same relationship does not hold, however, for bark near the top of the trunk. Top bark from four trees over 155 years old contained an average of 28 per cent tannin as compared to 30.5 per cent for bark from the corresponding location from two trees about 80 years old.

The results, on the whole, show that the tannin content of Sitka spruce

TABLE I. TANNIN CONTENT OF SITKA SPRUCE BARK
(All results on moisture-free basis)

Sample No.	Location	Date collected 1940	Tree No.	Age of tree years	Sampling height feet	Total solids per cent	Soluble solids per cent	Insolubles per cent	Non-tannins per cent	Tannin per cent	Purity ¹ per cent	Fixable tannin per cent	Sugars reducing per cent	Sugars total per cent	Diameter of thickness tree where sampled inches
1	Near Copalis, Grays Harbor County, Wash., S. E. ¼, sec. 32, T. 19 N., R. 11 W.	Mar. 20	1	135	3	55.3	53.7	1.6	16.5	37.2	69	..	2.7	6.9	..
2		Mar. 20	1	135	40	32.7	27.7	5.0	7.4	20.3	73	..	1.1	3.3	..
3		" 20	1	135	110	37.4	32.1	5.3	9.6	22.5	70	..	1.4	4.6	14
4		" 20	2	..	30	47.0	42.7	4.3	10.7	32.0	75	..	1.8	5.0	..
5		" 20	2	..	50	47.2	43.8	3.4	11.9	31.9	73	..	2.0	5.4	..
6		" 30	1	176	4	22.3	19.7	2.6	8.5	11.2	57	6.7	1.8	4.2	50 ½-¾
7		" 30	1	176	80	35.2	32.8	2.4	12.7	20.1	61	11.0	2.1	5.8	34 ½-¾
8		Apr. 1	1	176	155	42.5	40.7	1.8	14.9	25.8	63	13.1	2.5	7.3	12 ¾-¾
9	Quinalt River Valley, Jefferson County, Wash., sec. 31, T. 24 N., R. 8 W.	Mar. 28	2	156	4	29.6	26.0	3.6	10.7	15.3	59	..	2.1	5.4	46 ½-¾
10		" 28	2	156	110	33.9	29.7	4.2	13.0	16.7	56	..	2.5	6.7	26 ½-¾
11		" 28	2	156	180	52.4	49.4	3.0	19.2	30.2	61	..	3.7	9.8	10 ½-¾
12		Apr. 1	3	176	6	26.0	24.1	1.9	10.4	13.7	57	..	2.0	5.4	42 ½-¾
13		Mar. 28	5	140	6	36.2	31.8	4.4	11.5	20.3	64	..	2.0	6.2	26 ½-¾
14	Quinalt River Valley, Wash., sec. 33, T. 24 N., R. 8 W.	" 28	4	180	5	31.4	27.0	4.4	9.8	17.2	64	..	1.8	4.7	30 ½-¾
15		" 28	6	216	5	35.4	29.1	6.3	10.4	18.7	64	..	1.8	4.9	83 ½-¾
16	Siletz Bay, Lincoln County, Oregon, N. E. ¼, S. W. ¼, sec. 2, T. 8 S., R. 11 W.	Apr. 11	7	176	4	31.0	27.6	3.4	10.2	17.4	63	..	1.7	4.5	60 ½-¾
17		" 11	7	176	100	59.0	55.3	3.7	22.3	33.0	60	..	2.7	8.6	30 ½-¾
18		" 11	7	176	170	58.2	53.4	4.8	24.8	28.6	54	..	2.9	10.7	12 ½-¾
19	South Lincoln Beach, Lincoln County, Oregon, N. W. ¼, S. E. ¼, sec. 28, T. 8 S., R. 11 W.	" 11	8	186	4	31.9	25.0	6.9	8.9	16.1	64	9.4	1.4	4.4	40 ½-¾
20		" 11	8	186	90	53.5	48.0	5.5	19.4	28.6	60	..	2.0	8.3	23 ½-¾
21		" 11	8	186	160	50.9	47.0	3.9	19.8	27.2	58	13.4	2.3	8.8	9 ½-¾
22		Apr. 10	1	81	3	43.3	40.1	3.2	15.4	24.7	62	11.8	2.1	6.9	20 ½-¾
23		" 10	1	81	60	55.1	51.5	3.6	20.8	30.7	60	14.0	2.9	9.6	12 ½-¾
24		" 10	1	81	120	60.1	56.5	3.6	23.1	33.4	59	14.8	3.4	10.6	8 ½-¾
25	Neskowin Creek, Tillamook County, Oregon, S. E. ¼, S. E. ¼, sec. 5, T. 6 S., R. 10 W.	" 10	2	78	3	37.0	33.2	3.8	13.3	19.9	60	..	1.7	6.4	29 ½-¾
26		" 10	2	78	60	46.6	43.3	3.3	18.9	24.4	56	..	2.2	8.1	16 ½-¾
27		" 10	2	78	120	56.0	53.1	2.9	25.6	27.5	52	..	2.5	12.4	7 ½-¾
28		" 10	3	79	4	40.9	35.9	5.0	15.6	20.3	57	..	1.8	7.1	23 ½-¾
29		" 10	4	70	4	57.4	52.5	4.9	21.0	31.5	60	..	2.1	8.8	22 ½-¾
30		" 10	5	24	4	54.4	50.1	4.3	23.7	26.4	53	12.7	2.9	11.2	8 ½-¾
31		" 10	6	24	4	51.3	46.7	4.6	22.8	23.9	51	10.7	2.8	9.5	8 ½-¾

¹ Purity on soluble solids basis.
² Collected December 20, 1939.
³ Center cut probably about 60 feet.

bark is uniformly quite high except for that from the lower part of the trunk of old trees. This is the location where the bark is thickest and has the highest proportion of tannin. It is also the oldest bark on the tree and, consequently, has been subjected to the longest weathering. Whereas the average for all samples was 24.1 per cent tannin, if the eight samples from the base of old trees are excluded the average is raised to 26.8 per cent, or about 11 per cent more than that for western hemlock bark.

Moss or other growth on the trunk of the tree probably causes some lowering of the tannin content. For example samples 6 and 12 (Table I) contained only 11.2 and 13.7 per cent tannin, respectively. They were covered with moss whereas most of the other samples were free from it. Moss may destroy tannin either by some direct action or by increasing the effects of weathering by keeping the bark moist for longer periods.

A few results on fixable tannin are given in Table I for comparative purposes. As is typical with practically all tanning materials the values for fixable tannin are materially lower than those found by the regular hide powder method of the American Leather Chemists Association. For Sitka spruce bark fixable tannin equals about one-half of the total tannin.

Qualitative tests made on over half of the samples show that the tannin is of the catechol type.

The sugar content of the bark is only moderately high. It increases with height of sample from the ground and decreases slightly with age of tree. The range in total sugars was from 3.3 to 12.4 per cent. Clarke and Frey,⁷ using the same method, reported 16.9 per cent total sugars in an eastern hemlock bark, 17.4 per cent in a chestnut oak bark, 2.4 per cent in a mangrove bark, and 4.5 per cent and 9.8 per cent, respectively, in two samples of wattle bark.

Data on the actual leather-making qualities of Sitka spruce bark have not been acquired. Skivers tanned in the laboratory are comparatively light in color and approach the shade produced by chestnut oak bark. A few small pieces of heavy hide have been tanned without difficulty, using ground spruce bark alone.

Although the bark has a high tannin content and probably satisfactory tanning properties, it possesses the objectionable feature, from the commercial viewpoint, of being very thin and, consequently, of low yield per tree. Based on the samples in this study the thickness ranges from about $\frac{1}{16}$ to $\frac{1}{2}$ of an inch, with an average of around $\frac{3}{16}$ of an inch. Considering the size of the annual cut, the low yields of bark per tree, and the limited opportunities for peeling in the woods, it would appear that a large volume of tanning extract could not be obtained from this source alone. In favorable locations, however, it is possible that the production of tanning extracts from western hemlock bark might be supplemented and augmented by the utilization of Sitka spruce bark.

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Discussion

C. G. TELANDER: I am afraid I have nothing to add to this paper. It is sufficient in itself. But I think it is timely at this moment, when we are trying to find substitute materials within the country.

T. F. OBERLANDER: I noticed one thing: that the sugar content was fairly high, which might indicate that the extract may act more like oak bark than hemlock. I wonder if they have given that any consideration? There was no mention of that made.

R. W. FREY: No, we have really not gotten into any experiments on the tanning qualities of the material, other than just some preliminary ones in the laboratory. What you say would be indicated by the results on sugar content. The color, which has nothing to do with your point, does approach that of oak bark.